MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

PTH0016 – MODERN PHYSICS & THERMODYNAMICS

(All Sections / Groups)

14 FEBRUARY 2023
2.30 P.M – 4.30 P.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 3 pages excluding cover page and appendices with FOUR (4) questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answer in the Answer Booklet provided.

4. All necessary workings **MUST** be shown.

QUESTION 1 (15 MARKS)

a) A 5.0 cm tall object is placed 50.0 cm to the left of a converging lens with a focal length of +20.0 cm. A convex mirror with a focal length of -17.0 cm is placed 45.0 cm to the right of the lens based on **Figure Q1(a)** below.

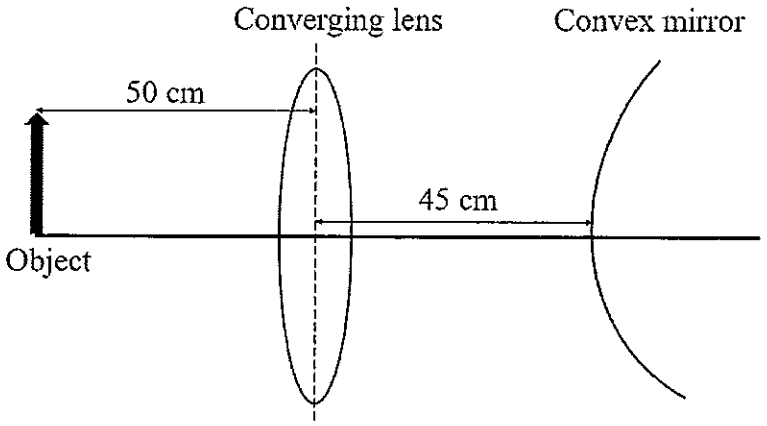

Figure Q1(a)

(i) Calculate the final image distance, measured relative to the mirror.

[5 marks]

(ii) Determine whether the final image is real or virtual.

[0.5 mark]

(iii) Calculate the overall magnification.

[3 marks]

(iv) Determine whether the final image is upright or inverted, with respect to the original object.

[0.5 mark]

(v) Determine whether the final image is smaller, larger or same size, with respect to the original object.

[0.5 mark]

b) **Figure Q1(b)** shows a ray of light in air is incident at an angle of 55.0° on the surface of some benzene contained in a shallow tank made of crown glass. Determine the angle of refraction of the light ray when it enters the glass at the bottom of the tank. Given that the index of refraction of benzene is 1.501 and crown glass is 1.517.

[3 marks]

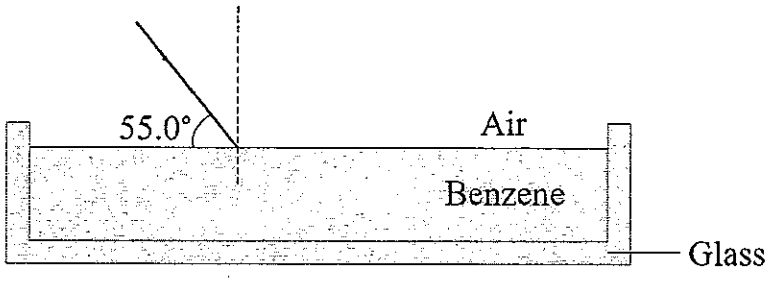

Figure Q1(b)

Continued...

c) You are given a slide with two slits cut into it. You shine white light on the slide. The second-order color spectrum is seen on a screen 4.0 m away. On the screen, the red light with a wavelength of 700 nm is separated from the violet light with a wavelength of 400 nm by 8.33 mm. Determine the separation of the two slits, *d*.

[2.5 marks]

QUESTION 2 (10 MARKS)

a) The photoelectric effect is studied using a tungsten. The work function of tungsten is 4.5 eV. The incident photons have energy 4.8 eV.

(i) Calculate the threshold frequency.

[1.5 marks]

(ii) Calculate the maximum kinetic energy gained by the electron emitted by the tungsten.

[2 marks]

(iii) Determine the stopping potential.

[1 mark]

b) A hydrogen atom undergoes a transition from the third excited state to the second excited state.

(i) Find the energy of the emitted photon in joules.

[2 marks]

(ii) What is the wavelength of the emitted photon?

[2 marks]

(iii) For an unexcited hydrogen atom (ground level), what is the energy required (in eV) to free the electron in the atom (ionized)? [1.5 marks]

QUESTION 3 (10 MARKS)

a) Calculate the mass of a sample of pure $^{40}_{19}K$ with an initial decay rate of $2.0\times10^{5}\ s^{-1}$. The half-life of $^{40}_{19}K$ is 1.28×10^{9} year. [4 marks]

b) Calculate the energy emitted in the following decay process,

(i) $^{218}_{84}Po \rightarrow {}^{214}_{82}Pb + {}^{4}_{2}He$

[2 marks]

(ii) $^{218}_{84}Po \rightarrow {}^{218}_{85}At + {}^{0}_{-1}e$

[2 marks]

(Atomic mass values:
$^{218}_{84}Po = 218.008965u$, $^{214}_{82}Pb = 213.999798u$, $^{4}_{2}He = 4.002602u$,
$^{218}_{85}At = 218.008965u$)

c) The uranium isotope $^{233}_{92}U$ undergoes alpha decay. What are the mass number and atomic number of the daughter nucleus? [2 marks]

Continued...

QUESTION 4 (15 MARKS)

a) What do you understand by the following?

(i) Thermal equilibrium [1 mark]

(ii) First law of thermodynamics [1 mark]

(iii) Conduction [1 mark]

(iv) Convection [1 mark]

(v) Specific heat capacity [1 mark]

(vi) Isothermal changes [1 mark]

(vii) Heat [1 mark]

b) 7200 J of heat is required to change m_{ice} kg of ice at 0°C to steam at 100°C. Calculate the value of m_{ice}. Given the latent heat of fusion of ice at 0°C is 333.70 $kJkg^{-1}$, the specific heat capacity of water is 4186 $kJkg^{-1}K^{-1}$ and the latent heat of vaporization of water at 100°C is 2256 $kJkg^{-1}$. [3 marks]

c) 2.50 L of an ideal gas at 20°C is heated and expanded at a constant pressure of 5 atm. As its temperature increases to 127°C, calculate

(i) the new volume of the gas. [2.5 marks]

(ii) the work is done by the gas. [2.5 marks]

Given that 1 L = 10^{-3} m^3.

End of questions.

APPENDIXES

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.60×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J s
		=	4.14×10^{-15} eV s
Speed of light in vacuum,	c	=	3.00×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.02×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^9 N m^2 /C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N m^2
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T m/A
1 atmosphere pressure,	1 atm	=	1.013×10^5 N/m^2
		=	1.013×10^5 Pa
Wien's displacement constant		=	2.90×10^{-3} mK
Speed of sound in air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km
First Bohr Raduis,	a_o	=	0.053 nm

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LIST OF FORMULAS

$$\sin\theta_1 + \sin\theta_2 = 2\sin\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\cos\theta_1 + \cos\theta_2 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angles

$D(x,t) = D_M \sin(kx \pm \omega t \pm \phi)$

$$v = \sqrt{\frac{F_T}{\mu}} \qquad v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}} \qquad v = (331 + 0.60T) \qquad v = f\lambda$$

$$f_n = \frac{nv}{2L} \qquad f_n = \frac{nv}{4L} \qquad \lambda_n = \frac{2}{n}L \qquad f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\} \qquad f = \frac{R}{2}$$

$$d\sin\theta = m\lambda \qquad d\sin(\theta) = \left(m+\frac{1}{2}\right)\lambda \qquad a\sin(\theta) = n\lambda$$

$$n_1\sin\theta_1 = n_2\sin\theta_2 \qquad n = \frac{c}{v}$$

$$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right) \qquad r_n = \frac{\hbar^2}{mke^2}n^2 \qquad L = mvr_n = n\hbar$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] \qquad \frac{1}{\lambda} = \frac{mk^2\ Z^2e^4}{4\pi\ c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \qquad \lambda = \frac{h}{p}$$

$$R = R_0e^{-\lambda t} \qquad \lambda = \frac{\ln 2}{T_{1/2}} \qquad Q = (M_X - M_Y - M_a)\,c^2$$

$$pV = nRT \qquad k = \frac{R}{N_A} \qquad N = N_0e^{-\lambda t}$$

$$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L} \qquad \frac{\Delta Q}{\Delta t} = e\sigma AT^4 \qquad \frac{\Delta Q}{\Delta t} = IeA\cos(\theta)$$

$$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT \qquad U = \frac{3}{2}nRT$$

$$Q = \Delta U + W \qquad W = \int dW = \int_{V_i}^{V_f} P\,dV \qquad W = P\Delta V$$

End of page.